ENGINEERING EDUCATION

Bulletin of the

Society for the Promotion of Engineering Education

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BOARD OF INVESTIGATION AND COÖRDINATION.

In 1922 the Society, acting on the report of its development committee, created a Board of Investigation and Coördination for the purpose of stimulating within each engineering school a careful inquiry into the philosophy of engineering education which underlay its work, the sources and preparation of its students, the curricula which should be provided for its students and the objectives to be aimed at in its training.

With the confirmation of a generous grant by the Carnegie Corporation of funds to meet the expenses of the Board for a three-year period and with the appointment of a Director of Investigations the project has passed from a stage of preliminaries to one of actualities. Offices are being established in the Engineering Societies Building, 33 West 39th Street, New York, and a start has been made toward the creation of the Director's staff.

The plan involves a careful study, as aforesaid, in each college from its own viewpoint, but further than that it involves the coördination of these studies in order that they may be made most useful to engineering education as a whole. It is the plan of the Board that the Director shall get in touch with the several engineering colleges by correspondence and to such a degree as possible in person, and particularly that he shall get in touch with geographical sections in person, in order that the studies to be undertaken in the several colleges may be so related as to give results that can be coördinated and made useful to all.

The Director aims to establish these contacts as early in 1924 as practicable. In the meantime he will be engaged in winding up his present duties and in formulating plans for the consideration of the Board. Contacts are also being established with the agencies representing the interests of industry,

business management, the professional societies and public administration which will coöperate in the study.

The Board and the Director appeal for the support of every engineering school and every individual member of the Society for the work which the Society is thus undertaking.

The bulletin of the Society, ENGINEERING EDUCATION, will be used for the purpose of disseminating information regarding the project and the results as they come forth, in order that all may have the opportunity of scrutinizing and discussing them.

In the period which will intervene before the regional conferences and direct contacts with the colleges can be undertaken, the officers of the several schools and the members of the Society in general can be of great assistance to the Director by writing to acquaint him with local problems and conditions and to suggest subjects for study within the scope of the general project.

On behalf of the Board of Investigation and Coördination,

C. F. SCOTT, *Chairman,*
F. L. BISHOP, *Secretary,*
W. E. WICKENDEN, *Director of Investigations.*

THE 1924 MEETING.

The University of Colorado reports that plans are well under way to provide for a large attendance at the S. P. E. E. meeting to be held in Boulder next summer. Since Boulder lies at the foothills of one of the most attractive regions of the Rocky Mountain range, special efforts are being made to give every one who desires, an opportunity to get into the mountains. Furthermore, arrangements are being made to construct an automobile camp adjoining the campus, so that those who drive out will have every possible convenience.

Dean Evans has appointed Professor J. A. Hunter as chairman of the General Committee. The chairmen of the subcommittees are as follows: Housing: W. C. Huntington; Board: W. C. DuVall; Registration: S. L. Simmering; Meeting Places: F. S. Bauer; Reception: J. B. Marcellus; Information: H. J. Gilkey; Transportation: C. L. Eckel; Entertainment: M. S. Coover; Publicity: W. O. Birk; Printing and Stenographic Work: F. G. Allen; Recreation: O. C. Lester; Ladies Entertainment: Mrs. H. S. Evans.

The Council is balloting on the dates for the meeting and by the returns now in the office of the Secretary, the meeting will begin Wednesday, June 25, and close Saturday, June 28.

EVALUATION OF THE STUDENT.

BY O. J. FERGUSON,

Vice-President; Dean, College of Engineering, University of Nebraska.

In this Society and in our other national engineering societies we long have studied the problems of the education of engineers. Of course, we recognize that these problems can never be settled, because even the questions themselves are in a constant state of flux. By the time we have a complete set of answers tabulated for the current edition, the author has brought out a new edition and has changed the problems! We must, therefore, continue to pursue the fleeing solutions.

What have we not asked ourselves?—What shall we teach? Whom shall we teach? How shall we teach? What is the field we would serve? How does our product coördinate with the need? Can we assort our raw material? How may we develop our teachers? Each one of these typical questions covers broadly, and frequently we begin to delimit the discussion to narrower or more special fields by querying as to what we shall teach whom,—or even how we shall teach what to whom.

Basically, the teaching profession should look upon its efforts as fruitless, its results incomplete and unsatisfactory, unless it succeeds in all of four functions. It must train the student's mind, body and soul to do, and do well. It must lead the student to recognize and analyze his own capacities and responsibilities. It must give him a comprehension of the meaning and the specific duties of an active life of service. It must help him to orient himself in the field.

These several features are overlapping and interdependent. Success in self-analysis and knowledge of the engineering profession are prerequisite to the orientation of the man. A technical training cannot be achieved without establishing outside engineering contacts and affording opportunities for a study of oneself.

This program contemplates much more than a technical training. It is not belittling the work of the job in which we are engaged to say that this part of it is one of the least of the things we are expected to accomplish. It is complimentary to the profession to place upon it the burden of these great duties.

The Board of Investigation and Coördination of this Society is planning a vigorous attack upon the problems of analysis of the field of engineering and our capacities to serve its needs. It is a profound problem, in the solution of which we may have abundant opportunity to assist.

We are also making the beginnings of a study in the evaluation of the student's capabilities. Psychology and intelligence tests will help us there, but these are of value principally from our own angle.

There is one element still missing, namely, the *self-evaluation* of the student. He must, more or less consciously, determine for himself what his chief characteristics are, how they compare with those of other men, what his limitations are. He must know what his body is capable of doing for him, as to the amount of work, the delicacy and precision of execution. He must recognize his type of mind, his social inclinations. He must study his processes and habits. He must gage his courage, his perseverance, his patience. The whole gamut of attributes must be run from ability to zeal. He must have standards by which to measure himself. And, above all, he must know that his conclusions will be worse than valueless unless he is honest with himself.

The average university student has made little start in this direction, and he is not well prepared to initiate such a study. Many of the men have never consciously considered the subject. There is an opportunity for us to direct them toward this end by utilizing a part of the time of the freshman orientation courses now being given in many institutions. They need more information as to methods of procedure. They must establish reference standards. They need to perceive what characteristics are important,—to what extent some are

assets and others liabilities. The matter of relative importance is difficult to discern. And in all of this introspection, the student must be cautioned, for he is treading on rather dangerous ground and viewing things which may unduly discourage him if he takes a pessimistic viewpoint in his analysis.

What is being done by members of the society to meet these needs? Are there those who are having distinct success?

THE ENGINEER AS A LEADER IN INDUSTRY.

BY OLIVER S. LYFORD,

National Industrial Conference Board, New York City.

FOREWORD.

Proper selection and training of new men for positions of administrative and technical responsibility in industry are vital to the economic development of our country. The growing complexity of industry, as of all society, adds continually to the burden of those who occupy leading positions; hence they must be selected with increasing care and given a steadily broader and more thorough training.

A primary object of the engineering school is to develop young men for effective service in industry. It therefore follows that in the close coöperation between the engineering school and industry lies the means for the accomplishment of the aims of both.

Realizing the importance of this problem, the National Industrial Conference Board has joined with the Society for the Promotion of Engineering Education in appointing an Advisory Joint Conference Committee of industrialists and of educators and administrators in engineering schools to help guide the study of the problem.

It is the purpose of this report to show clearly the interrelationship between the engineering schools and the industries and the need for coöperation of the two organizations interested in the development and successful functioning of leadership in industry. It presents a survey of the situation and is intended to suggest the groundwork for an educational-industrial structure, important elements of which are later to be made the subjects of special study.

INTRODUCTION AND SUMMARY.

In an industrial system so complex and varied as that of the United States, problems of adjustment and readjustment are constantly arising. Some of these problems reach their own solution with the passage of time, others must be faced as they arise and the best thought brought to bear upon them.

Among these problems is that of fitting the education of those who are to direct the processes of industry, in subordi-

nate as well as in high managerial positions, to the ever-changing conditions of industry itself. Its solution is not simple nor can it be expressed in a few categorical statements of what should or should not be done. The whole broad field of the nation's manufacturing activities must be surveyed with the eyes of the trained observer who realizes that the needs of the next generation must be considered in the educational plans of to-day.

It was with this end in view that this study was made. The report offers a picture of the present situation in industry viewed from the standpoint of the relationship of engineering schools to the industrial establishments. An estimate of the needs of industry in the next few years is then given, both as to the quality and number of new men that will be required if industrial progress is to be maintained. For many of the positions of administrative and even technical responsibility in industry, adequate training is satisfactorily secured by methods other than those of regular engineering courses, but in this report attention is concentrated upon the responsibilities that rest upon industry and engineering schools individually and jointly in the selection and training of candidates for industry's commanding positions.

This report may be summarized as follows:

1. There is a rapidly growing need for administrative and technical ability in practically all lines of activity. This is especially true of the manufacturing and mechanical industries.

2. There is an increasing demand for graduates of engineering schools to enter upon work which will fit them for positions of administrative as well as technical responsibility. This, apparently, is because courses of education in engineering and applied sciences have been highly successful in the the early development of both kinds of talent.

3. The demand for young men with capacity for becoming administrative or technical leaders is already far greater than the number of such men now being graduated from the engineering schools.

4. It is, nevertheless, more important that a greater proportion of the graduates of engineering schools be young men of high quality than that the total number of graduates be increased. Therefore admission to these schools should be based on selective tests for fitness, intelligence and character as well as for knowledge.

5. The preparatory schools can perform a great service to industry as well as to the students by properly evaluating the advantages of the engineering schools and guiding toward those schools the boys who have, or in whom can be developed, an interest in producing things. Such boys should develop into industrialists.

6. There is a growing opinion that the engineering schools should provide a thorough grounding in fundamentals of engineering and applied sciences, rather than specialized training. Such a grounding is best accomplished when accompanied by actual contact with industry as well as by work in classroom and laboratory.

7. There should be more and better training courses in connection with industrial establishments to supplement the educational courses of the colleges.

8. Close coördination of educational effort is therefore necessary between industrialists and educators to meet the need for leaders.

I. The Need for Trained Leadership in Industry.

On approaching the subject of higher education for service in industry, three broad questions immediately suggest themselves:

1. Do the industries in the United States need more or fewer engineers than the number now being graduated from engineering schools and colleges?
2. What kind of men do the industries require from the engineering schools and colleges and what should be the nature of their education?
3. Finally, what are the responsibilities of industry in this matter?

In order to answer these questions it is important to review the major problems which are facing the industries of the

United States to-day and the demand created by these new problems for men qualified to assume and properly to discharge administrative and technical functions. The final answers to these questions require coöperative study and experiment, but the direction of such study and experiment should be determined in the light of a full consideration of the conditions which confront industry to-day.

The New Problems of Industry.

The growing importance of trained leadership in industry is evident not only from the new developments in the organization and processes of industrial production and distribution during recent years, but in the present position of American industry in relation to world conditions. The history of American industry during the past few decades reveals a picture of transition and growth unparalleled in rapidity and extent. The marked shifting of the population from agricultural to industrial pursuits has tested our powers of organization and assimilation. The expansion of industry has been accompanied by vastly increased complexity of industrial operations, and the grouping of greater numbers of workers in corporate units has placed upon employers an increased social responsibility toward their employees and toward the life and affairs of the community. All of these changes have created problems of human, social and political relationships in which industry and society as a whole have become increasingly dependent upon trained technical and administrative leaders.

Some of these problems have not only grown more complex and intensified in consequence of the recent World War and as a result of the disruption of industry and the subsequent cyclical depression and expansion, but they have also become international in character. Many of the economic factors with which American industry has to deal are now world-wide in scope and influence. To the extent to which the United States enters more vigorously into world economic affairs,

there is increasing pressure upon it for greater industrial efficiency and for broader and more far-sighted leadership. As the nations of Europe and Asia emerge from the tangles of the depression caused by war and social upheaval, as they take advantage of the educational benefits resulting from extensive foreign intercourse, and as they are driven by economic necessity to larger and more efficient production, their competition with the industries of the United States for world markets will necessarily be greater and keener than ever before.

France, whose methods of production were largely individualistic before the war, has learned much about mass production. The advantage of efficient machinery and methods during the war became so apparent that the French laborers later demanded of the employers the adoption of such improved productive processes.

England, whose labor unions had been obstructive toward the adoption of modern machinery and methods, was forced during the war to improve vastly her mechanical equipment and throw off restraints on production. Some of the old restrictions have been reinstated, but both employers and workers retain their war-won capacity to increase production and decrease costs when conditions require.

Germany has been stimulated by her financial and economic conditions greatly to enlarge and improve her plants and their equipment, and if her economic relations with the rest of the world become stabilized, her industries will be in a position to compete in world markets more vigorously than ever.

China and Japan also have gained largely in industrial ideas and methods as a result of the experience of their nationals in war work in European countries.

In short, not only the internal changes in American industry but its changed external relations will inevitably lead the American employer in the future to require the keenest intelligence and the highest skill in his personnel in order to retain American industrial supremacy. Many employers are already feeling the demand for readjustment to these internal

and external conditions. The engineering schools and colleges are being combed for recruits capable of rapid advancement to responsible positions. On the other hand, during the years since the war, many young engineers have been searching for positions in industry, and this has led some employers to assume that the engineering schools are turning out an oversupply of such talent. There is an evident lack of adjustment between engineering schools and colleges and the industries. To correct this condition, it is important that the industries, on the one hand, should have an accurate understanding of what reasonably may be expected of the schools, and that the educators, on the other hand, should be properly informed of the requirements of industry, both as to number and as to the qualifications of the men needed for industrial leadership. With the mutual understanding thus established, it will be possible better to adjust the educational product to industrial requirements and to use it more intelligently and effectively after its entrance into the field of industry.

The Present Requirements of Industry.

The demand of American industry for men with effective educational training for technical and administrative leadership may be fairly gauged by the present ratio of persons in positions of responsibility to the total number gainfully occupied in the United States. Of the 41,600,000 persons who were gainfully employed in 1920, according to the United States Census for that year, less than 4 per cent. planned the activities and directed the energies of the whole working force. This is concisely shown in Table I, in which the figures as to the administrative, supervisory and technical experts in each group of gainfully occupied persons are derived from the United States Bureau of the Census Bulletin entitled "Comparative Occupation Statistics for the United States, 1920."

In the group designated as administrators, supervisors and technical experts are included major officials, managers, superintendents, technical engineers, designers, draftsmen, inventors, architects, chemists, assayers, metallurgists and auditors,

together with one quarter of the number of foremen, overseers and inspectors in agriculture, mining, manufacture, construction, trade, transportation and public service. It was assumed that three quarters of the foremen, overseers and inspectors are not sufficiently distinguishable from the group of wage earners and workers to be included in the category of those who plan, supervise and administer the business of the nation.

TABLE 1.

PERSONS GAINFULLY OCCUPIED, MALE AND FEMALE, UNITED STATES, 1920.

	Total Persons Gainfully Occupied.	Administrators, Supervisors and Technical Experts.
Agriculture and animal husbandry.....	10,953,158	200,000*
Extraction of minerals.....	1,090,223	43,558
Manufacturing and mechanical industries..	12,818,524	600,194
Transportation	3,063,582	104,658
Trade	4,242,979	228,560
Public service	770,460	33,983
Professional service	2,143,889	264,898†
Domestic and personal service.....	3,404,892	4,665
Clerical occupations	3,126,541	29,613
	41,614,248	1,510,129

* Rough approximation.

† Includes engineers and other technical persons.

According to these figures, there were in 1920 approximately 1,500,000 positions in the business structure of the United States which must be gradually taken over by the youths who have the ability and who shall have received training which will enable them to assume the responsibility of the various forms of major and minor leadership.

Future Requirements.

The question next arises as to whether this demand for potential experts and administrators is likely to increase or decrease, and as to the probable extent of such change in the coming years. The present position of American industry and the problems confronting it, briefly described above, natu-

rally raise a strong presumption that an increasing proportion of planners and leaders will be required to keep pace with the growth, complexity and responsibility of American industrial and commercial life. In the census figures for the past few decades there is statistical support for this conclusion and a rough means of gauging the probable number required to fill such positions of responsibility in the near future. Table 2 shows the proportion of administrators, supervisors and technical experts to the total gainfully occupied for the census years, beginning with 1870. The figures for each year were reduced as nearly as possible to the same basis as those of 1920, although there are slight differences due to variation in the classifications in the different census returns.

TABLE 2.

NUMBER OF ADMINISTRATORS, SUPERVISORS AND TECHNICAL EXPERTS IN PROPORTION TO PERSONS GAINFULLY OCCUPIED, UNITED STATES. (United States Census of Occupations)

Year	Total population continental U. S.	Persons gainfully occupied		Administrators, supervisors and technical experts*	
		Total number of persons	Per cent of total population	Number of persons	Per cent of those gainfully occupied
1870 ..	38,558,371	12,505,923	32.4	170,000	1.25
1880 ..	50,155,783	17,392,099	34.7	245,000	1.40
1890 ..	62,622,250	22,735,661	36.2	450,000	1.74
1900 ..	75,994,575	29,073,233	38.3	716,000	2.46
1910 ..	91,972,266	38,167,336	41.5	1,245,000	3.27
1920 ..	105,710,620	41,614,248	39.4	1,510,000	3.60
1930 ..	119,861,710	50,341,918	42.0	1,900,000	3.80

* 1930 total population estimated by United States Bureau of the Census. Persons gainfully occupied in 1930 estimated by National Industrial Conference Board. The number of administrators, supervisors and technical experts in each year was approximated from census figures on the same general basis as used for the year 1920 in Table 1, and as explained on page 6.

This table shows how rapidly since 1870 the number of administrators, supervisors and technical experts has increased. Even more significant is the fact that the ratio of these to the

total number gainfully occupied has increased steadily, particularly since 1890, when the era of mass production began. Whereas the proportion of persons gainfully occupied has increased from 32.4 per cent. of the total population in 1870 to 39.4 per cent. in 1920, the proportion of administrators, supervisors and technical experts has increased from 1.25 per cent. of the total gainfully occupied in 1870 to 3.6 per cent. in 1920, an increase in numbers of over 1,300,000.

What is likely to be the situation in 1930? The United States Census Bureau estimates that our population by the next census will be nearly 120,000,000. If, also, the proportion of the gainfully occupied continues to increase as it has in the past, the number of such persons in 1930 may be expected to be about 50,300,000 and the number of administrators, supervisors and technical experts may be as high as 1,900,000. In other words, American industry may need 400,000 more persons for positions of responsibility in 1930 than it used in 1920. This is in addition to the replacements necessary during the ten-year period.

The reasons for this growth in the demand for experts and leaders lie in the change of methods by which industrial work is performed. They consist mostly in the development of corporations, in the increasing use of machinery, power and other labor-saving devices and in the elaboration of methods of control in production and distribution. Methods of mass production greatly increase the amount of product per worker, but require a relative increase in the proportion of planners and administrators.

These facts and figures demonstrate that both the normal progress in industrial methods and the approaching new competitive conditions will require a more rapid increase than ever before in the quality and number of trained experts and leaders.

The Kinds of Talent Necessary.

A feature of great importance for the consideration of industrialists is the proportions of the different kinds of talent

necessary in the upper strata of our industrial structure. It would be helpful if the requirements of the next ten years could be divided into the approximate number of each class, such as designers, research engineers, general foremen, superintendents, managers and executives. Although this does not seem possible, because of lack of adequate information, a study of the requirements in mechanical and manufacturing industries alone will afford some interesting suggestions of value to industry generally. In Table 1 it was shown that in these industries there are about 600,000 persons with administrative and supervisory functions, exclusive of engineers and those in other professional occupations. It is estimated that about 150,000 of the professional men and women (see the seventh group in Table 1) are employed in or associated with these industries and that there are, therefore, a total of about 750,000 persons occupying leading positions in these industries, or approximately one half of the total number filling positions of responsibility in the United States. About 20 per cent. of these positions are technical in character and the remainder are supervisory and administrative. If there is assigned to each of the existing establishments, according to size, a normal organization of officials, engineers, superintendents, etc., the general picture of the grouping of major technical supervisory and administrative positions in the manufacturing and mechanical industries as a whole would be somewhat as shown in the pyramid in Chart 1.

Success in Groups A, B and C is achieved in nearly every case only after years of service and development in Group D. The persons who occupy the positions in the three upper groups received most of their practical training and experience while in Group D and the future occupants must do likewise. In general, therefore, the education given in our engineering schools should be that necessary for entrance into Group D. Service in this group, in competition with other college men and with the greater number who lack the advantage of higher education but have the will to win, enables the engineering graduate to progress rapidly and to develop

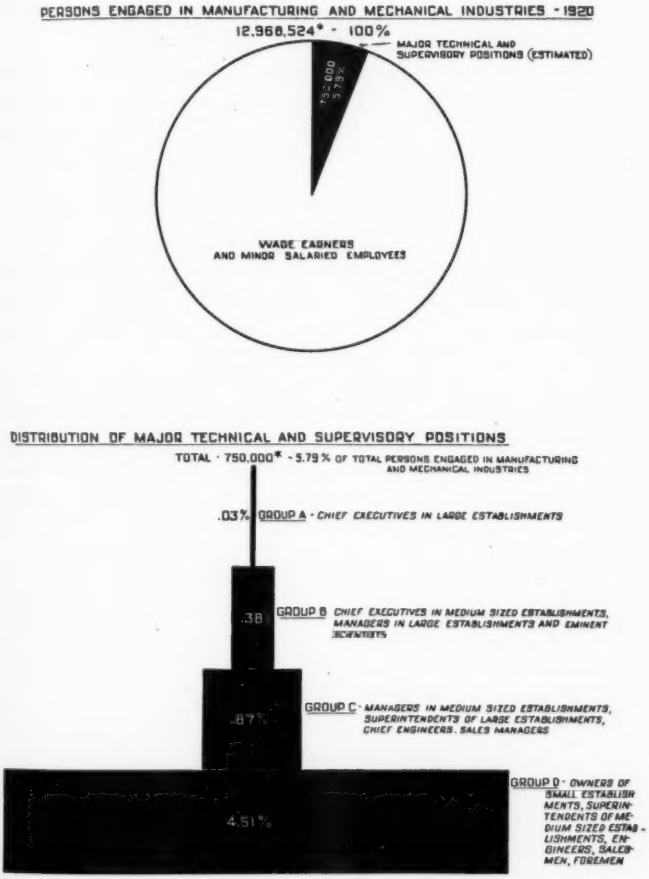
under observation of his chief. Through his energy and application he will have the opportunity to develop the qualities of leadership necessary for the higher positions. The attention of industrialists, educators and students should be concentrated primarily upon the securing of an adequate supply of the best talent for Group D. Contrary to the popular impression held by many young men, the pinnacle of this pyramid is not attained by a short step from college but only by thorough training in the group at the base. The student and the educator must realize that progress in this group requires sufficient time to get a proper insight into the methods of business. Coöperation between industrialists and educators should aim to make the base of this pyramid adequate in every sense.

At present the demand for administrative talent is more pressing than for technical experts, but in the conditions of international competition now developing, research will be of the utmost importance. Success will lie in the improvement of technical processes, utilization of by-products and reduction of waste as well as in better methods of production and distribution. The supervisory and administrative leaders in our industrial structure exceed the technical experts numerically at least four to one, but no one should lose sight of the fact that both groups are essential and that in each there are positions of highest responsibility and honor.

The important thing is that the natural talent of each person be found and that the industrialists as well as the educators stimulate its development and use to the highest degree.

At the present time our engineering schools are turning out about nine thousand graduates per year, many of whom go into occupations outside of industry. There are no available statistics as to the number of replacements and hence the number of vacancies to be filled in Group D each year, but it is obvious that these replacements, added to the great number of new positions annually created, constitute an annual demand for recruits equivalent to many times the number of

CHART 1. Major technical and supervisory positions, manufacturing and mechanical industries, United States, 1920.


PERSONS ENGAGED IN MANUFACTURING AND MECHANICAL INDUSTRIES - 1920
12,968,524* - 100%
MAJOR TECHNICAL AND SUPERVISORY POSITIONS (ESTIMATED)
750,000
5.79%
WAGE EARNERS AND MINOR SALARIED EMPLOYEES
DISTRIBUTION OF MAJOR TECHNICAL AND SUPERVISORY POSITIONS
TOTAL - 750,000* - 5.79% OF TOTAL PERSONS ENGAGED IN MANUFACTURING AND MECHANICAL INDUSTRIES
.03% GROUP A - CHIEF EXECUTIVES IN LARGE ESTABLISHMENTS
.38 GROUP B CHIEF EXECUTIVES IN MEDIUM SIZED ESTABLISHMENTS, MANAGERS IN LARGE ESTABLISHMENTS AND EMINENT ENGINEERS
.87% GROUP C - MANAGERS IN MEDIUM SIZED ESTABLISHMENTS, SUPERINTENDENTS OF LARGE ESTABLISHMENTS, CHIEF ENGINEERS, SALES MANAGERS
4.51% GROUP D - OWNERS OF SMALL ESTABLISHMENTS, SUPERINTENDENTS OF MEDIUM SIZED ESTABLISHMENTS, ENGINEERS, SALESMEN, FOREMEN

*150,000 engineers, designers and research men are included in Groups B, C and D. Figures are approximated from United States Census of Occupations.

competent candidates graduated each year who desire such positions. There are many highly desirable "top" positions in Group D, such as the ownership or management of small establishments, and the competition for these is well worth while. On the other hand, there is undoubtedly a large amount of waste involved in the supply and turnover of the personnel of Group D. Furthermore, men often remain in positions in which their best talents are not utilized. Such maladjustments of persons over thirty five years of age are especially unfortunate. Improved methods of selection and training in the schools and in industry itself should save time and expense in getting men placed in their logical positions. This involves a comprehensive study of the movement of American youths in schools and in industry and the methods of selection, education and training employed in both.

II. The Educational Problem.

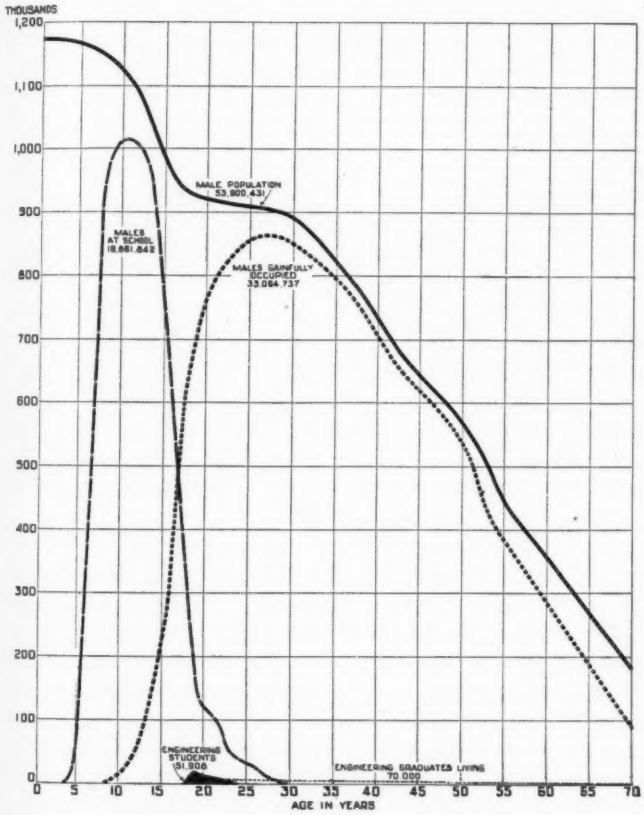
Few industrialists have been able to give much thought to the broader educational problems. Many have concluded from their personal experience that the only effective industrial education is that obtained within industry itself. On the other hand, many have found that education in college and engineering schools, and association with intelligent instructors and students, exercises a strong influence upon the capacity of young men to advance rapidly to positions of responsibility. A brief statement of the situation as a whole will be of assistance.

Chart 2 presents graphically the relation of our educational system to the working population and to the total population of the country. It should be noted that the data in this chart pertain to males only, whereas the previous data have included both males and females; also that the figures showing totals on this chart are represented by the areas between the curves and the base line.

This chart shows strikingly, in the first place, that during the ages from twenty five on, the male population of the country is almost wholly a working population. The proportion

of the males gainfully occupied to the total male population of the United States within the age limits of thirty five and

CHART 2. Male population, number in school and number gainfully occupied, United States, 1920.



fifty is about 96 per cent. A recent survey of the city of Cleveland showed a proportion of 98 per cent. gainfully occupied between the ages of twenty one and forty five.

According to the best information available, there are about 350,000 living male graduates of colleges and engineering schools. Many of these are in occupations which are dissociated from, or only indirectly associated with, industry, and it is to be presumed that a considerable additional number have retired from gainful occupations. It is therefore apparent that there are many less than 300,000 male college graduates, academic as well as scientific, in industrial, financial and commercial occupations, or considerably less than 20 per cent. of the total number of those who plan and administer the productive work of the nation. The total number of engineering graduates is about 70,000. The line representing these engineering graduates on Chart 2 lies so close to the base line as to be hardly distinguishable therefrom, and the smallnesss of their proportion to the total gainfully occupied is apparent.

It is the boys and men between the ages of fifteen and twenty five in schools and colleges, and the boys and men between those ages who are gainfully occupied, who come chiefly into the problem of correlation of industry and education. Since these include persons in all varieties of occupations as well as in all kinds of schools, the problem is vast and complicated, requiring the broadest survey of our educational system and of the industrial situation in relation thereto.

The phase of this problem which is naturally receiving most of the attention of the engineering schools, and which is the main consideration of this report, is illustrated as to numerical magnitude by the dark triangle at the bottom of the Chart 2, representing the 51,908 students in the engineering courses of the colleges and technical schools in 1920. Being such a small proportion of the total and yet having such great potentiality, it is obvious that much depends on the methods of selection and training applied to this group.

The very smallness of this group is in itself ample evidence that the matter of its selection is of especial importance. Industrialists rightly look to the engineering schools for candidates to be trained for the higher positions of responsibility;

obviously there should be in this group as great a proportion as possible of high grade men.

The Engineering School.

The engineering school is an indispensable part of the general industrial system. Engineering education in the United States is now about one hundred years old; the first private school in this country for the education of engineers (Rensselaer Polytechnic Institute) is just completing its first century of existence. Development was slow at first, but due to the stimulus of the great expansion of industrial production after the close of the Civil War, the number and size of engineering schools grew until there are now 129 engineering intitutions and engineering departments in colleges with a total undergraduate enrollment of 51,908 in 1919–20 and 52,290 in 1922–23.

Throughout this period of development, the field of activity for engineering graduates has expanded continually. Not only have the lines of national activity broadened, but the proven capacity of engineering graduates has led industry to place them to an increasing degree in positions of leadership in many departments, thus shifting them more or less from the lines for which they were specifically prepared.

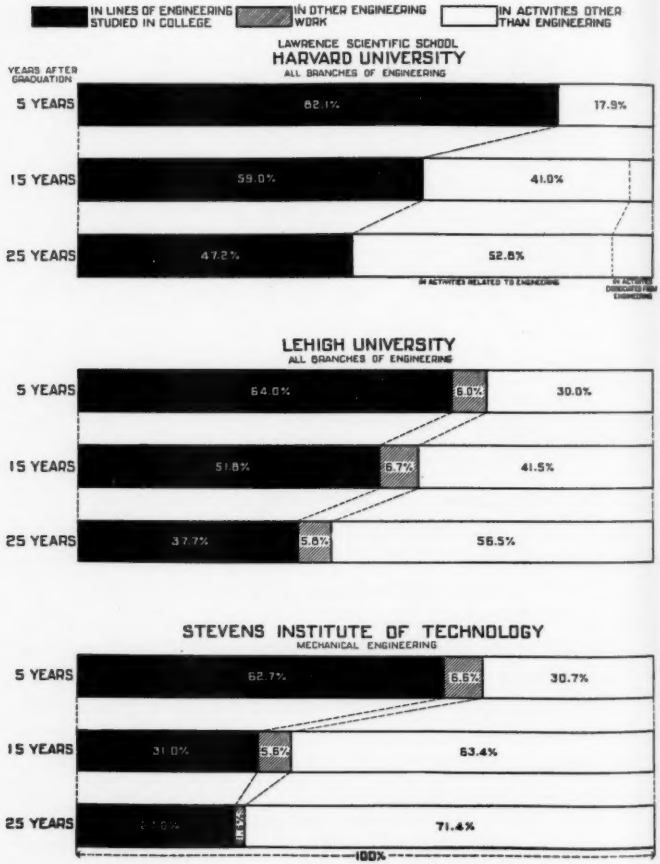
Tendencies of Engineering Graduates.

An investigation of the records of certain classes of graduates of different engineering schools and a classification of the positions held by these men when they have been out of college from five years to twenty eight years, affords the comparison shown in Chart 3 and 4. The graduates were classified in three groups: (*a*) the men who are still in the field of engineering work studied in college; (*b*) the men doing engineering work in some other field than that studied; (*c*) the men who have shifted from strictly engineering work to executive or commercial activities.

These charts indicate, in the first place, a marked variation in the shifting of engineering graduates to other lines of ac-

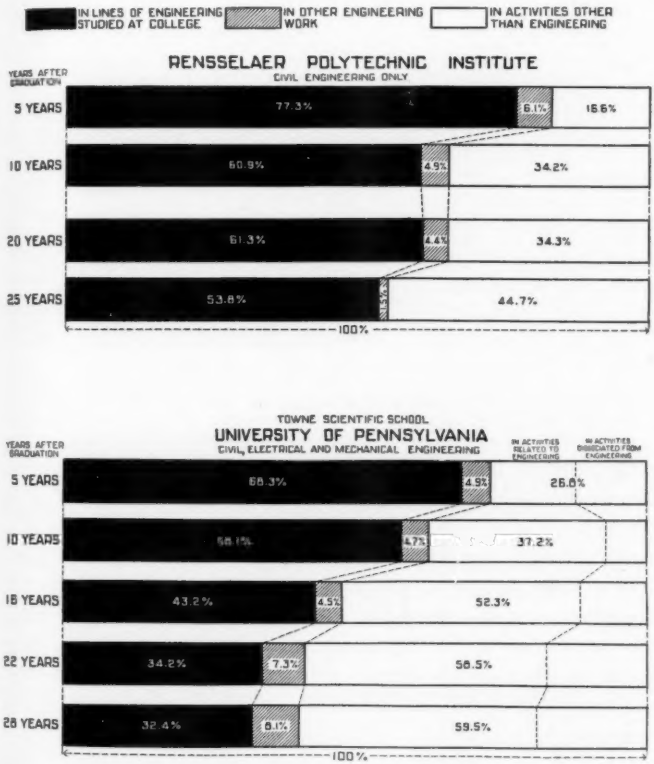
tivity as between the various institutions. One factor influencing this shifting may be the field of engineering work chosen. In the case of the classes of 1894 and 1895 from Rensselaer, the graduates were all civil engineers, while the

CHART 3. Occupation of engineering graduates, three technical schools, United States.



men from Stevens Institute of Technology were graduated as mechanical engineers. Consequently the charts suggest that in the field of mechanical engineering, closely related to fac-

CHART 4. Occupation of engineering graduates, two technical schools, United States.



tory industry, the shift from engineering into administrative and commercial work is likely to be on a larger scale than in the field of civil engineering. The graduates in a mixed group such as those from Lehigh University, Harvard Uni-

versity and the University of Pennsylvania show a somewhat more regular trend of shifting into other pursuits, falling between the records of Rensselaer and Stevens in this regard.

In the diagrams for Harvard University and the University of Pennsylvania, a dotted line divides the groups who entered upon activities other than engineering. The area to the left of this dotted line represents those whose activities related to engineering while the area to the right represents those who went into activities totally dissociated from engineering.

One important question is as to how many of the shifts from engineering to non-technical pursuits were of the nature of an advancement and how many were due rather to maladjustment. In some instances, the shifting has undoubtedly been due to failure rather than to success and the individual has left engineering work either because he discovered that he did not like it, or that he was much better suited to some other activity. In most cases, it is probable that the gradual shift with the years is evidence of a logical change of occupation.

Developments in Engineering Courses.

After a swing towards greater specialization in undergraduate work in the engineering schools, there is now a general movement toward unification of courses. Furthermore, whereas thirty years ago the colleges and the engineering schools were far apart in courses and in methods of education, they are now growing closer together. The colleges are providing more and fuller courses in science, and the engineering schools, by concentrating on the fundamentals rather than on technical training, are thereby approaching the traditions of the colleges. Furthermore, it is becoming more and more evident that

> "It is the business of the schools to train young men into fertile and exact thinkers, guided by common sense, who have a thorough knowledge of natural laws and of the means for utilizing natural forces for the advantages of man and the advancement of civilization. In other words, it is the business of engineering schools to produce, not finished engineers, but

young men with a great capacity for becoming engineers, the goal being attained by the graduates only after years of development in the school of life." *

Although a good technical expert seldom develops into a good executive, nevertheless successful industrial administrators and technical men should have certain characteristics in common, such as: A good grasp of the fundamentals of science, the ability to think logically and quantitatively, exactness of method, the habit of looking forward, sound economic theories, a large capacity to learn, and the ability to write and speak clearly and correctly.

When a boy is endowed with the faculty of thinking in exact and logical terms, and has an active interest in the mechanical and other scientific problems of life—in other words, when he has a "science mind," he will generally receive the best educational benefit from a course in engineering or applied sciences, even though his other characteristics qualify him for administrative rather than technical responsibilities. Moreover, men with such characteristics are needed throughout our entire social fabric. A very large proportion of the existing administrative, supervisory and technical positions are of a nature requiring the characteristics stated above.

The future of the country therefore depends upon an adequate supply of men trained in applied science and engineering who are forward-looking men.

That these ideas are spreading among industrialists, as they have already taken hold in the minds of educators is evidenced by the many expressions to similar effect in public addresses and private correspondence.

Suggestions from Industrialists.

The National Industrial Conference Board has received many valuable suggestions from prominent industrial and

* Dugald C. Jackson, "Methods of Teaching Electrical Engineering," Paper presented before the second Pan-American Scientific Congress, December 27, 1915–January 8, 1916, Government Printing Office, Washington, 1917.

railroad executives and others whose views were solicited regarding possible improvements in the training which men receive from the engineering schools, and regarding a closer coöperative relationship between the engineering schools and American industry. The principal recommendations, coming from 68 industrial executives, 13 railroad executives, 4 engineers, 3 educators, one editor and 6 governmental officials, may be summarized as follows:

That the method of selecting men for admission to the colleges be improved;

That the students be trained broadly and thoroughly in the fundamentals;

That the colleges do more to stimulate initiative;

That the instructors in technical subjects have more practical experience, and be selected for vision and high ideals;

That the students be given practical training in industrial establishments either

(*a*) By serving an apprenticeship or in some other way, before entering college, or

(*b*) By industrial work during student's vacations, or

(*c*) By supplementary industrial training after completing the theoretical course, or

(*d*) By practical training in industry coincidently with theoretical training in college, as in the coöperative courses at Cincinnati and elsewhere.

It is interesting to note that these various recommendations, based upon experience in many diversified interests, apply broadly to the preparation for all branches of industry. All the industrialists are more interested in the general character and ability of their recruits than in the specific knowledge required in any particular industry. There is a general conviction that the methods of selecting recruits for engineering schools must be improved and that the courses of instruction should be in certain fundamentals rather than in specific technical information and should be planned to stimulate original thinking, initiative, vision and high ideals. The greatest unanimity is shown in the opinion that practical training in industrial establishments is essential for both instructors and students, and most of the writers believe that

this industrial training of the student should be given before or during the college course.

Training in Fundamentals

In the suggestions brought forth by the inquiry above referred to, as well as in the meetings of the Advisory Conference Committee, much emphasis has been placed on the importance of adequate training in "fundamentals."

Speaking at a meeting of industrial engineers and educators, held at Pittsburgh in May, 1922, F. B. Jewett, Vice-President of the Western Electric Company said:

> "The industry with which I am connected is a highly technical one which is based on physics and chemistry and mathematics; but so are many of the big industries in our country and the more I see of them the more convinced do I become that the directors of these industries in the future are going to be drawn more and more from men who have a thorough grounding in the fundamentals on which the industries are based. In the old days it was not so, but each day we go on now, it becomes more clearly apparent that because the industries are technical because they are based on the fundamental science, they must be guided by men who have a thorough appreciation of the fundamentals because business is hardly more than mixing the dollar or cents with physics and chemistry and mathematics. Since engineering schools are the place where we expect to turn out men who are going to guide technical industries, we should turn out men who know the principles of the fundamental sciences; who know the method of combining fundamental sciences with the dollar and cents proposition and know English in a way to enable them to express clearly what they know, so that others may profit by it, because it does none of us very much good to be ever so wise if we cannot express our ideas to others.
>
> "It seems to me that if the engineering schools of the future are going to perform their function for the industries, they have got to get closer to the proposition of teaching and really inculcating the fundamentals. Let the matter of trying to make executives go, if you will. The men of executive ability will come to the fore in the general run of things, I think, provided the Lord gave them the right human

traits and provided they have a thorough grounding in the fundamentals."

Following him, E. M. Herr, President of the Westinghouse Electric and Manufacturing Company, said:

"I have been very much impressed with the discussion and especially by the points brought out by the last speaker. I heartily endorse his view of the importance of the fundamentals and of the idea of patient plodding in the minds of men who are going into industry. There is no royal road, to my mind, to a place of commanding importance in industry, or in any other business, and I do not believe that it is the function of educational institutions to try to teach young men to become captains of industry and administrators, or occupy very great and important executive positions. I do not believe that it can be done; I do not believe that that quality in man is capable of being taught in an educational institution. It has got to be developed in actual contact with affairs but it can be developed, and developed well, and only can be developed well, if the man who is engaged in industry is thoroughly grounded in the fundamentals of engineering and science."

While there is general agreement on this view that one of the leading essentials in education in relation to industry is an adequate training in and knowledge of fundamentals, there is wide variation in the meaning of the term "fundamentals." From the point of view of the industrialist, the term "fundamentals" means a general groundwork of useful knowledge but, more especially, a training in the power to use this knowledge in effective thought and action.

The fundamentals of engineering training may be stated as follows:

(*a*) Mathematics;
(*b*) The important principles of physics (mechanics, heat, light, sound, electricity, magnetism), chemistry, biology and geology, the interrelations of natural phenomena and the application of these principles to practical problems;
(*c*) The principles of economics and their application to industry and commerce;
(*d*) The principles that govern the relations between people, not only as applied to managers and men, but also as applied to governments and society;

(*e*) The history of nations;
(*f*) The art of clear and correct expression in speaking, writing and drawing.

The relative emphasis to be placed on each of these fundamentals is a matter to be determined for each engineering course.

Selection and Classification of Students.

Frequently throughout this study, the importance of better methods of selection and classification of students has been stressed. Coördination of effort to this end is necessary between industry, the engineering schools and the preparatory schools. Indeed, the latter must be given an adequate understanding of the functions and value of industry in the social system, without which they cannot properly direct into the engineering schools those of their students who have latent talent for engineering work, in its broadest meaning, and who would find their best opportunity in this field.

The greatest need of industry is for high grade men. Representatives of industry who visit the engineering schools in search of recruits invariably want the top men, but there are only a few to be had. The difficulty is that a large proportion of the graduates of the engineering schools each year are not of the right type for leading positions in industry, and many of these might have been better prepared for life in other ways.

This fact is well known to educators and is receiving much thought from them. Alone, however, they cannot solve the difficulty. College faculties can improve the tests for admission, but naturally their selections can be made only from the students who apply for admission. If the total number that come up to them from the preparatory schools is not large enough, they can do no more than take the best of those who present themselves. It should, however, be possible to reach back into the preparatory schools and begin the process of selection there to find the boys with the "science minds," who then may be guided towards the courses in engineering and

applied sciences. Industrialists must, for their own benefit as well as that of the American youth, give very definite assistance to the educators in this matter.

Although there is room in industry for more graduates than the engineering schools are now turning out, it is more important that a greater proportion of these young men be of high quality than that the total number be increased. Accordingly, requirements for admission should be such as to place a premium on intelligence, self-mastery, resourcefulness, courage, vision, openmindedness, patience, persistence, critical judgment, integrity, and other elements of character as well as the knowledge pre-requisite to the college courses.

Limitation of the undergraduate courses to the thorough education in the fundamentals and employment of students in industrial pursuits during the undergraduate period will afford time and develop the basis for a progressive and, in the end, more effective determination of the life work of the student, which is now done largely in a more haphazard way and principally in the last period of undergraduate training.

III. The Responsibility of Industry.

The responsibility of industry in connection with engineering education is much greater than has been realized heretofore. It is now evident that every industrial corporation of any considerable size must have a well thought out educational policy for the development of its leaders. An adequate policy involves a measure of assistance to the engineering schools and colleges in the development of their courses of study and in providing opportunities for practical experience for the students. Such a policy also involves adequate methods of training within the industry.

Many of the engineering schools are rich in buildings and equipment, but all need help in improving the effectiveness of the teaching force. Industrialists can assist in finding and developing men for this service, with the necessary qualities of character and personality as well as of knowledge. They can increase the esteem in which educators are held. They

can provide the opportunity for the instructors to maintain the necessary contact with industry and its needs and to become acquainted with the latest industrial methods and practices. They can thus increase the attractiveness of the teaching profession for men who have the teaching instinct and logically belong in this profession. These things are all necessary for the welfare of industry as well as for the advancement of engineering education.

Industrialists should realize that it is a primary motive of the colleges and engineering schools to provide the kind of education which industry demands. School shops were provided when industry expected its recruits to be generally familiar with shop practices. Courses in business administration are now being provided because industry is placing more emphasis on the need for administrative talent. Concentration on training in fundamentals will be the watchword of the schools if the demand therefor becomes general.

Industrialists can assist in devising ways and means of adequately testing the boys in the preparatory schools and in the colleges; also in making clear to the educators how the young men with different types of minds and different kinds of training fit into the industrial order. There should be reasonable consistency between the tests for admission to the engineering schools and for admission into industry.

The most tangible and immediate assistance of industry can be given through the development and expansion of existing facilities in industry for practical training of undergraduates during the summer holidays, or through coöperative courses of educational and practical training throughout the undergraduate period. Summer courses in shop practice and administration are highly desirable and more and better courses are needed for both students and instructors. Such courses, to be sufficiently effective, must be under the supervision of men with educational interests and obviously must not be limited to routine work, but must present many of the everyday problems which make the life of the industrialist interesting and stimulating.

The coöperative methods which have been inaugurated by the University of Cincinnati and some fourteen other schools in the United States * are producing admirable results, and these methods can undoubtedly be extended to advantage. Coöperation may, however, take many other forms and it is probable that additional methods will be developed. Graduate coöperative courses are effective for students who have obtained little or no industrial training during undergraduate years. One of the major benefits of the Cincinnati plan is the interest it has aroused among local manufacturers. This kind of interest is a fundamental necessity for the success of any plan of coöperation between industry and the engineering schools.

Industry can also accomplish much by greater encouragement to employees to undertake extension courses in engineering. A number of engineering schools are offering such courses which are supervised by representatives of schools and directed by representatives of industries. Sympathetic guidance by the employer is important for the success of this plan. Extension work of this character is a most valuable agency for promoting coöperation between the industries and the engineering schools.

Sympathetic guidance of both the college man and the non-college man presupposes a careful evaluation of the work of all employees and assurance to them that talent and effective work will be known to and appreciated by the management. Educators report a growing feeling among undergraduates that in most large corporations a young employee often is lost in a department and for many months may not come under the observation of the leading men of the organization. A large public utility company, the two largest manufacturers of electrical apparatus and a few other large corporations which have unusual and enlightened personnel departments, in many cases are getting the pick of the young talent, because of their attention to this problem.

* See article by Joseph W. Roe, entitled "Coöperative Plan of Engineering Education" in *Management Engineering* for May, 1922.

These are some of the ways in which industry can supplement the work of the educators. On the other hand, industrialists may profit greatly by the assistance which educators can give in developing methods of training suited to each establishment.

It is rapidly being recognized that during the last period of engineering education and the first period of engineering practice, the engineering school and industry have a common problem; and the closer the coöperation during this period of transition, the more beneficial will be its result for the young man, the school from which he graduates and the industry which he is planning to serve as his life work.

PROBLEM WORK IN ENGINEERING SCHOOLS.

BY EVAN THOMAS,

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Professor A. E. Kennelly's readable and illuminating report on engineering education in France, already published in ENGINEERING EDUCATION, contains the following passage, which cannot fail to be of interest to instructors in the technical schools of this country: "In their lectures the professors of engineering seldom employ arithmetical examples; although arithmetical examples frequently occur in the problems they assign for solution. They restrict themselves, as a rule, to algebraic expositions; to the abstract general case, rather than to the concrete example. . . . The students like to see an analytic presentation of a technical subject, and are captivated by an artistic demonstration of a proposition in classical form." In this respect the superiority of the French to the American student must be conceded. The latter is much more strongly attracted to the economic, technical and constructional phases of engineering education, and it is only of the very exceptional American student that it can be said that he is captivated by a finished analytical demonstration. And further, the average American student has no very keen appreciation even of an orderly, expeditious and neat solution of the arithmetical problems assigned. His interest is largely, if not exclusively, restricted to getting the numerical answer. If he succeeds in this he is satisfied and regards the methods pursued, the time consumed, and the general appearance of the work as matters of small consequence. It concerns him very little, if any at all, that much time and labor have been wasted and many liabilities to error incurred by faulty arrangement or no studied arrangement at all, inattention to simplifying expedients, overlooking opportunities for cancellation, the use of long multiplication and

division in the place of logarithms or the slide rule, and the employment of 6-place tables when 4-place tables would give as good a result. The late Professor T. H. Safford, of Williams College, one of America's greatest computers, was wont to deplore the American student's deficiency in the art of computation, and Professor Simon Newcomb, when he visited the Greenwich observatory, was struck with the contrast between the systematic way in which astronomical problems were solved in the English observatories and the haphazard methods of doing similar work in America. Signs are not wanting, however, of an awakened interest in this phase of engineering education in this country. At least one of our leading engineering schools has established a separate chair for problem work. The purpose of the following paragraphs is to suggest a few points to which, it is believed, attention could be profitably directed by those engaged in the training of engineers.

1. A glaring and wholly inexcusable defect in much problem work is in the writing of the Arabic figures. These symbols are among the most beautiful and useful creations of human genius, and easily take their place among those products which are accepted as having upon them the stamp of finality. There is no attempt to improve them or to displace them by superior forms. Without them most of our computational work would be impossible, likewise results of the highest benefit to mankind and most characteristic of an advanced civilization dependent upon extended computations. Early in his course the student should receive a thorough drill in writing these characters legibly and neatly, and all careless, slovenly, even though not wholly illegible work should be either rejected outright or severely marked down. Of course, it may be urged that this part of the student's training belongs to the preparatory schools, which is true enough, but inasmuch as a high percentage of entering students are, as a matter of fact, lamentably deficient in this respect there is only one course open, viz., to make up the deficiency in the college class rooms. Another offense against artistic effect, which

should not be allowed to go uncorrected, is the habit of using promiscuously in the same solution printed and script characters, a habit often acquired after entering college, usually in connection with drawing, a habit, too, often encouraged by the easy tolerance, if not by the example, of the instructor. This practice gives the work somewhat the appearance of a printed page in which different fonts have been drawn upon at random. This emphasis upon writing may seem a bit trivial, but a little care at this point greatly improves the appearance of the solution and helps to direct the attention of the student to the value and importance of good workmanship.

2. In the great majority of engineering problems the use of logarithms is not only a convenience but a practical necessity, yet, notwithstanding their frequent occurrence and acknowledged utility, many students have a rude awakening, often late in their academic careers and sometimes after graduation, to the uncomfortable fact that their command of logarithms is inadequate, due chiefly to a very imperfect understanding of the theory of radicals and also of algebraic subtraction. The late Professor Olney, one of the great mathematical teachers, if not one of the really great mathematicians of his day, once said that after an experience of nearly thirty years in examining students for admission to the University of Michigan not one in fifty could give a rational account of some of the simplest operations upon radicals, though a majority, probably, could be counted on to perform the indicated operations correctly. That was a good while ago and probably things have taken a turn for the better since that day, but it is true even now that a very high percentage of students are unable to handle radicals with intelligence and confidence. The theory of logarithms is still more or less of a mystery to many fairly good students.

To meet this condition ample opportunity should be afforded for a thorough review of the calculus of radicals with special reference to logarithmic theory. But exposition, however clear and thorough, is pretty likely to prove fruitless un-

less followed by extended practice, preferably under immediate supervision, in the solution of a large number of varied problems involving all the difficulties likely to be encountered in logarithmic computation, as, for example, the difficulty in evaluating decimals with fractional exponents. Negative characteristics are always puzzling to the beginner and the device of adding 10–10 often helps over seemingly hard places. Nevertheless the fact should not be overlooked that the device also serves to conceal from the student the real character of the numbers with which he is dealing and the operations to be performed upon them. It is better to postpone the use of 10–10 until a good understanding of the real significance of negative characteristics and some facility in their use are acquired. Then this familiar artifice may be safely and perhaps advantageously used, though there is much to be said in support of the late Professor Holman's contention that "the conventional method (10–10) serves no useful purpose, and that it is better and less troublesome in every way to retain the negative characteristic." A clear understanding of cologarithms and extended drill in their use should be insisted upon not only because of their aid to compactness in numerical work but also to strengthen the student's mastery of logarithmic computation. Any disposition on the part of the student to dodge the use of cologarithms in favor of more familiar but less felicitous methods should be discouraged.

3. The idea of speed naturally suggests itself in connection with problem work. Speed, however, is something which should be acquired in connection with professional work rather than in connection with preparation for that work. It is said that one great merit of Rankine was his ability to discriminate sharply between those branches of engineering knowledge which grow from daily experience and those which depend on unchangeable scientific principles. Speed should come with actual practice and not with the study of fundamental principles, with which the student is primarily concerned in college. His aim is to secure understanding, con-

fidence, and ability to apply principles with accuracy. A bank clerk whose knowledge of mathematics is probably not very extended, can compute the amount due on a note in much less time than an accomplished mathematician. The late Professor Bartlett of West Point, one of the best students of mechanics the country has produced, was not according to report a lightning calculator, and it is quite conceivable, and even probable, that a member of the engineering staff of a bridge company could compute the stresses in a given structure in much less time than he. Speed belongs with practice rather than with an understanding of fundamental principles.

4. A noticeable defect in many solutions is the apparent absence of any plan. The attack is made in a most haphazard way, and in many cases many random attempts are made before a solution is reached or the effort abandoned. It is desirable, from the standpoint of success and economy in solution, as well as from the standpoint of the educational benefit to be derived from this line of work, that the student be thoroughly instructed to think out the solution in advance and even to make a rough estimate of the result, jotting down such points as may aid the memory and the formation of a definite plan. This is a good exercise in itself and a protection against egregious errors. This preliminary work will include the tabulation of all the quantities entering into the problem and the adoption of some general principle in accordance with which the solution is to be effected. In mechanics, for example, the choice may lie between the principle of moments and the parallelogram law, or the employment of both may be seen to be advantageous. A skeleton scheme is then prepared, and in the case of a numerical solution everything is put down which can be, even known characteristics of logarithms, before any actual computation is begun. Problems in trigonometry lend themselves admirably to this purpose. In this way errors are more easily detected, and if the work is to be checked by another the solution should be so arranged as to be followed with the least amount of effort. A

solution is an argument conducted in shorthand, the answer the conclusion arrived at, and it goes without saying that the argument should be put in the best possible form.

5. Problem work, if it is to yield satisfactory results, must be in the fullest sense coöperative and continuous throughout the course. Every department in which numerical computations occur should share in it. It goes without saying that the chief responsibility rests upon the department of mathematics, which offers the best opportunities for direct instruction and extended practice. The qualifications of the mathematician and those of the computer are not necessarily identical, but the instructor of mathematics in an engineering school should be at least a competent computer, familiar with the more rapid calculations necessary in applied science no less than with the more cumbrous methods of pure mathematics, and the study of good solutions should form an integral and important part of the work in all mathematical classrooms. Trigonometry, for example, offers an admirable opportunity for drill in the solution of problems. It comes early in the student's academic life, the data are simple, the logarithmic work considerable, the value of an orderly arrangement apparent, the means for checking close at hand, and the practical importance of the subject readily acknowledged, the last a consideration of no small value. In analytic geometry computations connected with the plotting of many transcendental functions bring a strong challenge to the student's ingenuity in devising an advantageous arrangement of the numerical work. All branches included in the mathematical curriculum offer useful material to the alert instructor intent upon preparing the student to solve well the problems likely to appear in professional practice.

The primary responsibility of the department of mathematics is readily acknowledged. But the work, to be successful, must be coöperative and continuous. The most painstaking effort of the mathematical instructors will fall short of its aim if it is understood among the student body that "anything goes" in other departments provided only that the final

result is correct, which means that the student has got the answer. But if, on the other hand, there is in the institution a solid tradition that all work, in whatever department, will be carefully scrutinized with respect to arrangement, method and neatness as well as to the accuracy of the result, the task of the mathematical department will be greatly lightened and the benefits to the student correspondingly improved.

In fact, other departments have peculiar advantages in teaching problem work effectively. The problems come much nearer to those which occur in actual practice than is possible in the more formal courses in mathematics, and the student is able to see more clearly their bearing upon his subsequent professional activities. His familiarity with the data involved keeps pace with new requirements in mathematical and numerical work. What place tables to use? How many decimal places to retain? How far can the slide rule be trusted to give the desired accuracy?—the answers to these questions and many others like them are dependent upon judgment no less than upon familiarity with mathematics, and this judgment can best be formed in classes in which are studied those subjects which provide the data for the problems. In this way the student escapes many of the fanciful problems which have their origin in the inventive brain of the mathematician and which abound in works on pure mathematics. He also escapes the more practical problems whose data are not familiar to him, a point of no small importance, since the educational purpose is largely defeated when he is subjected to the uncomfortable feeling that he is working in the dark or is a mere copyist. Through this coöperative and continuous process the student will be consolidating, improving and extending his previous knowledge of mathematics. The symbols of differentiation and integration will gradually lose their terror and come to be regarded as most welcome and useful additions to the equipment of an educated engineer.

6. Close supervision of problem work in every department is highly desirable. The presence and guidance of the instructor supply the condition under which the student will

work at his best. Kindly criticism and sympathetic encouragement instill hope and stimulate ambition. The student has now a definite task before him and a definite result which he knows is within reach. A wrong departure is provided against, or if a false step has been taken it can be quickly retraced, thus saving valuable time otherwise given to misdirected and fruitless effort. Supervision, primairly concerned with manipulative processes, supplies the condition under which the fundamental principles underlying the operations may be most advantageously explained. The alert instructor will be quick to seize these opportunities to teach principles as well as processes, and principle is best grasped when given a visible representation, as it were, in a concrete problem. The traditional blackboard method is insufficient. The sections are usually too large for the blackboard surface available, and the instructor is necessarily occupied with those remaining in their seats. Besides, no provision is made by this method for the completion of unfinished work, which, for obvious reasons, is an important consideration. The writer has secured very satisfactory results in this connection in mechanics from a method suggested by his colleague, Professor Robinson, of the department of mechanical engineering. A part of the hour, sometimes the whole hour, is given to problem work. Each student provides himself with a drawing board, 12 x 10 inches, cross section paper and the necessary drawing instruments. A problem is now assigned and is worked out under the supervision of the instructor. Should the period not be long enough for its completion the work is continued out of class, but a sufficiently good start has been made in the class to enable the student to proceed with a reasonable hope of success. In case of a very long problem the work may be resumed in class later. In case of work done out of class it may be best not to assign the same numerical data to any two students.

7. The educational value of problem work well done is considerable. The contents of the educational purpose are large and varied and anything like a complete tabulation is impos-

sible. But any teaching seeks to replace blurred vision of a principle by a clear understanding of it. This problem work is admirably calculated to accomplish. Another result aimed at the awakening of intellectual interest, and to this problem work makes a valuable contribution. It is the common experience of mathematical instructors that the intellectual pulse of the class is appreciably quickened with the shifting of the discussion from abstract principles to illustrative problems, in which the abstract idea is given a visible representation. Still another element in the educational purpose is to develop the habit of responsible thinking. For this purpose problem work is admirable, for the results of one's thinking are readily checked, which is not the case in many other subjects in the curriculum because the elements entering into the problem are too numerous and too obscure. Mathematical problem work can be used successfully to bring home to the student the value of thoroughness in the small details of everything attempted, whether work or play. Careful, accurate and neat work leads to a state of mind which will make itself felt in other than mathematical subjects. Finally, it brings home to the mind the necessity of taking into account all the factors which can possibly affect the final result. In the respect the value of the training received in problem work, conducted under competent leadership, is immeasurable, for it is an exercise in analyzing a problem with respect to reality and not in respect to what one would like to find or not to find. One of the choicest products of education is a mind prepared to analyze a situation in this manner. The social, reform and political problems of the day demand for their solution just this mental habit.

DISCUSSION: THE MAN AND THE JOB.

BY WM. F. TURNBULL.

New York University.

Referring to the article by Mr. G. M. Eaton in the May number, entitled "The Man and the Job," the statements of this article are at variance with the well-known laws of the distribution of human characteristics, which engineers in their over specialized pride are often willing to dismiss as "frills." By this I mean Experimental Psychology, Economics and Statistics which show that all phenomena involving life follow the Probability Curve. For an infinite number of units, say the whole human race, we have the symmetrical bell shaped curve whose middle ordinate gives the number of persons possessing an average amount of the given characteristic and whose decreasing ordinates on each side of the middle give the number of persons above or below the average by an amount measured by the corresponding abcissa. For each characteristic the equation of the curve has a different coefficient giving greater or less breadth to the "hump." This curve has been found to apply not only to physical dimensions of the body, length of life, etc., but also to intelligence. It has even been applied to wages in Professor Moore's brilliant book, showing from wage statistics that these follow the same distribution as human abilities, namely the Law of Probability.

There is therefore the best of reasons for supposing that the difficulty of jobs is distributed also according to the Law of Probability, and the difference between an ideal world where every man had the job he was just fitted for and every job found a man just capable of filling it perfectly can be mathematically stated in two ways: First, the coefficient of the demand or job curve is different from that of the supply or man curve, as illustrated in Fig. 1, or, Second, the demand and supply curve each depart from the Law of Probability so that

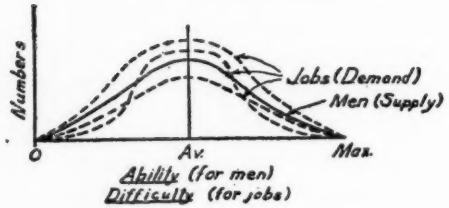


FIG. 1.

the middle ordinates do not coincide, even though the two coefficients are the same, as shown in Fig. 2. Fig. 3 shows the combined effect.

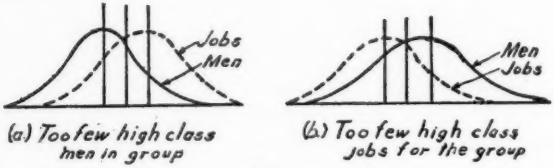


FIG. 2.

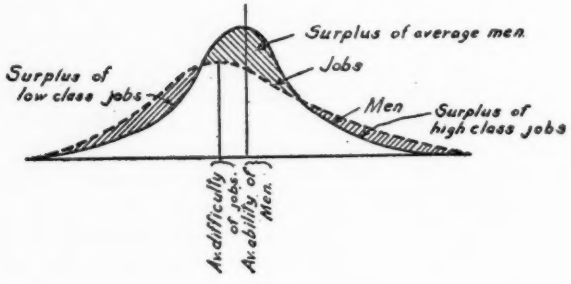


FIG. 3.

Thus the over supply and deficiency of men of a given degree of ability or jobs of a given degree of difficulty will be indicated by the differences in the ordinates of the same abcissa. A modification in social or industrial conditions might change the job curve and training might change the man

curve. The unsymmetrical curves will always occur in the observation of small or special groups, and the greater the specialization, the greater will be the asymmetry.

Now the Practice Curve or curve of increasing proficiency with progress of time has also been studied statistically for a great many different jobs, but its equation has not been worked out. Its general shape is shown in Fig. 4. Profi-

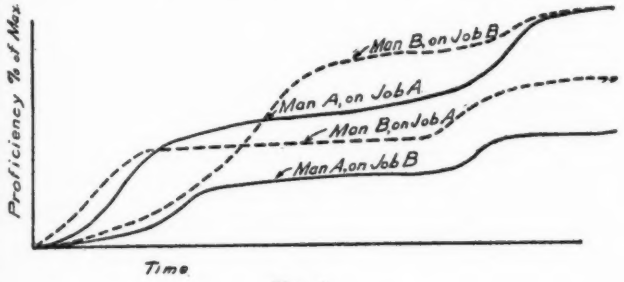


FIG. 4.

ciency first increases at a rapid rate as shown by the slope of the tangent at any point, then more slowly, finally almost not at all, then more rapidly and finally more slowly. Almost every observation bears out the fact that the job grows easier as time goes on and the ability to take on more difficult jobs varies with the capacity of the individual.

It is safe to say that no job requires a total absence of responsibility nor an infinite responsibility. However, as in the discussion of all probability curves, an unusually large or small quantity is treated as infinite or infinitesimal, that is the curve has zero ordinates for finite amounts instead of being asymptotic. Mr. Eaton, however, departs from well-known mathematical laws in confusing the curve of the distribution of ability with the practice curve and calling each a hyperbola. As a matter of fact, the former is the Probability Curve slightly modified by the limited number of units considered, and the second or dynamic curve which might be called "life" to use Mr. Eaton's phrase, is the Practice Curve.

Another confusion in Mr. Eaton's article is the statement—"Let X equal the number of men competent to shoulder the load." It is evident if Y is the burden of responsibility, that X must be the number of men just suited to that burden, otherwise instead of getting a curve we shall get an area, and Mr. Eaton's X is in fact an area, that is, all the men equal to or greater than the responsibility. Thus the same men would be counted for all responsibilities below their maximum, according to the ordinary meaning of the word competent. The point is then indefinite in an area of the probability curve, that is, the area to the right of any given ordinate in the ability curve, or to the left of any given ordinate in the job curve.

In place of Mr. Eaton's prism, there should be constructed a surface intersected by probability and practice curves, as illustrated in Fig. 5.

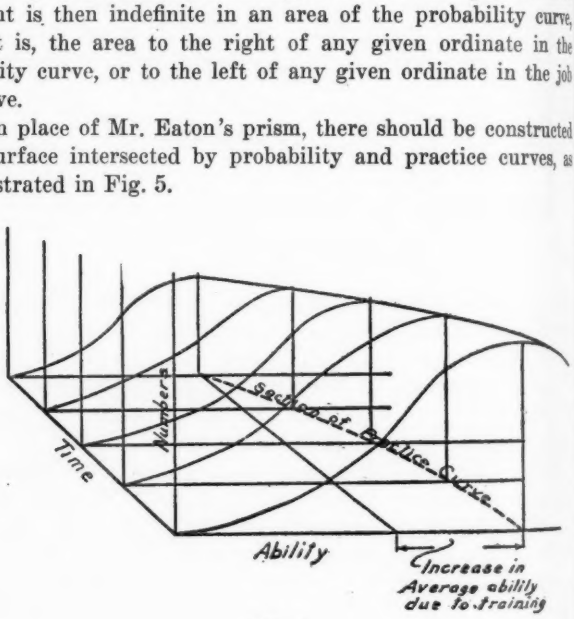


FIG. 5.

SOCIETY ITEMS.

The first installment—$6,000—of the Carnegie Corporation grant to the Society for the Promotion of Engineering Education was received December 13, 1923.

Mr. W. E. Wickenden, Director of Investigations, is now located at Room 1607, Engineering Societies Building, 33 West 39th Street, New York, N. Y.

Information booklets have been mailed to all members. The Secretary will be glad to supply you with additional copies. An application blank was enclosed in the booklet and each member is asked to secure at least **FIVE** new members.

Information cards for the 1924 year book—March number of ENGINEERING EDUCATION—were mailed to all members. Please return these as soon as possible. If your card did not reach you, send the following information to the Secretary, Dean F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.: Name; Title; Address; Classification.

Dean Hugh Miller, George Washington University, Washington, D.C., is organizing a Section of the Society. All members residing in that territory are urged to get in touch with him.

DIVISION OF DEANS AND ADMINISTRATIVE OFFICERS.

The Committee in charge of the meeting of Administrative Officers and Deans of Schools of Engineering has fixed on the date of January 25–26, 1924, as the time for the meeting at the University of Michigan, Ann Arbor. We wish to have this a large meeting so that we may discuss in a national way problems relating to the engineering schools. Realizing that there will always be difference in the methods of presentation and in the content of the curricula of engineering schools, we do feel that there are certain problems which are common to us and the discussion of these problems will be helpful to the administrative officers and faculties of our engineering colleges.

Dean Cooley has arranged to reserve all of Michigan Union for our entertainment during this session and we have selected a time at which President Burton may be present. The time of our meeting also corresponds with the meeting of the Board of Regents of the University of Michigan, and it may be that a number of them will desire to attend some of our sessions.

On Friday night, January 25, the Musical Department of the University is giving one of its concerts at which time Chaliapin will be the artist. We are invited to this concert.

I am sure this session will prove of value to you and I hope you will immediately mark the date on your calendar and make plans to attend. Arthur M. Greene, Jr., Chairman, Princeton University.

Dean Cooley has appointed the following committee to arrange for the meeting: A. H. Lovell, *Chairman,* C. E. Wilson, J. R. Nelson, G. M. McConkey, J. H. Cissel, A. O. Lee, C. E. Love, F. R. Finch, W. F. Wood, A. F. Lindblad, H. Bouchard.

A MEETING OF REPRESENTATIVES DESIGNATED BY NATIONAL ENGINEERING SOCIETIES FOR CONFERENCE RELATING TO COÖPERATION WITH THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, CORNELL MEETING, JUNE 1923.

Present: F. L. Bishop, A. M. Greene, D. C. Jackson, S. P. E. E., M. E. Cooley, Federated American Engineering Societies; W. W. Bullock, J. T. Faig, A. S. M. E., J. H. Dunlap, A. S. C. E., Prof. Reise, A. I. M. and M.E., C. F. Scott, N. E. L. A., W. G. Raymond, A. R. E. A., and W. H. Timbie, A. E. R. A.

The meeting was called to order by Chairman Jackson of the Committee of the Society for the Promotion of Engineering Education on Coöperation with the National Engineering Societies who made a statement as follows:

We have here represented the four founder engineering societies. We also have here represented three notable engineering societies which are associated with the industrial aspects rather than professional aspects of engineering, in addition to the representatives of the S. P. E. E. Can this Committee plan coöperation between the engineering societies which will lead them to take up carefully a study of the scope of engineering for the aid of engineering schools in the planning of their curricula?

The Chairman then suggested two questions for the consideration of this committee of representatives and urged careful consideration:

I. Can the engineering societies formulate a definition giving the scope of engineering which will aid the engineering schools to fix the field within which their curricula should reside.

II. Should the founder engineering societies take that up by themselves in case it is not undertaken by the societies already, or should they have associated with them engineering societies which are more directly connected with the industrial aspects of engineering.

There are certain aspects to the question that may be properly emphasized. One of these is, What kind of training should be considered as fundamental for engineering? This affects the curriculum, and industry and other activities to which engineering graduates are attracted may aid in the answer to the question. Another phase, the annual number of men who (considering the growth of industry and the growth of population of this nation) should be delivered each year into engineering circles with an engineering education by the engineering schools.

Secretary Dunlap (A. S. C. E.) suggested that the consideration which the national societies might give to this question need not be limited to the one phase, namely, the scope of engineering.

Mr. Wickenden (A. I. E. E.) pointed out that the Joint Conference Committee of the National Industrial Conference Board has staked out a large area of investigation and we should expect an indication of the scope and their procedure from them. We have a right to expect the program or order of events which the S. P. E. E. and the National Industrial Conference Board propose to take up to be outlined in order to avoid duplication.

After general discussion participated in by all present, Mr. Wickenden recommended a memorial to the Directors of the National Engineering Societies and such other societies as the S. P. E. E. may deem wise, requesting an appointment of a joint conference committee of counsellors in order that certain aspects of engineering education which are conceived to be within the concern of engineering societies may be dealt with in the engineering school curricula proposed by the S. P. E. E.

No definite resolutions were passed but it was expressed as the sense of the Conference that the appropriate procedure would be for the S. P. E. E. to address such a memorial to the Boards of Government of the four founder engineering societies, and that for the present the societies more directly associated with the industrial aspects rather than professional aspects of engineering need not be approached on the question.

COLLEGE NOTES.

University of Akron.—In spite of more stringent entrance requirements, the enrollment of new students in the College of Engineering and Commerce of the Municipal University of Akron is slightly larger than ever before, and, as usual, the the numbers dropping out of the upper classes are relatively very small. The first year of the Commercial Courses under the Coöperative scheme begins very auspiciously, and the positions offered to commercial and engineering students is noticeably in excess of our enrollment. The attitude of the industries, not only in Akron, but often at considerable distances, grows constantly more appreciative, and a number of concerns have taken the initiative toward closer coöperation even than heretofore. The recasting of the curriculum so as to include in the Freshman year courses in Elementary Mechanics and six weeks work for each student of introduction to the methods pursued in each of the three Engineering Laboratories, Civil, Electrical, and Mechanical, have assisted us to keep young men who are not fitted for engineering from continuing the course.

University of Arizona.—O. B. Goldman has been appointed Assistant Professor of Mechanical Engineering; P. J. Beatty as instructor in mechanical engineering; A. W. Voorhees as instructor in geology; P. P. Spafford instructor in electrical engineering; F. L. Ransome as Professor of Economic Geology; A. A. Stoyanow as Professor of Paleontology and Stratigraphy.

The mechanical engineering laboratory has been completely renovated and much new equipment has been purchased, and the laboratories in petrography, advanced crystallography, and optical mineralogy have been enlarged and improved. Dr. F. N. Guild has been appointed as Professor in this work, being transferred from the chemistry department.

The electrical laboratory has added to its equipment, some a.c. and d.c. machines, a 40 h.p. motor generator, and some Allis Chalmers apparatus.

Michigan College of Mines.—The College has received bids from contractors for the construction of the new Metallurgy Building to replace the one destroyed by fire. It is expected that work will begin very soon after the contract has been awarded. The plans of the new building call for a structure and equipment that will be second to none in the country. The laboratories will contain the most up-to-date facilities for instruction in metallurgy; the College will not only endeavor to present the subject according to the most modern pedagogical methods, but also to keep closely in touch with the art as it develops in industrial practice.

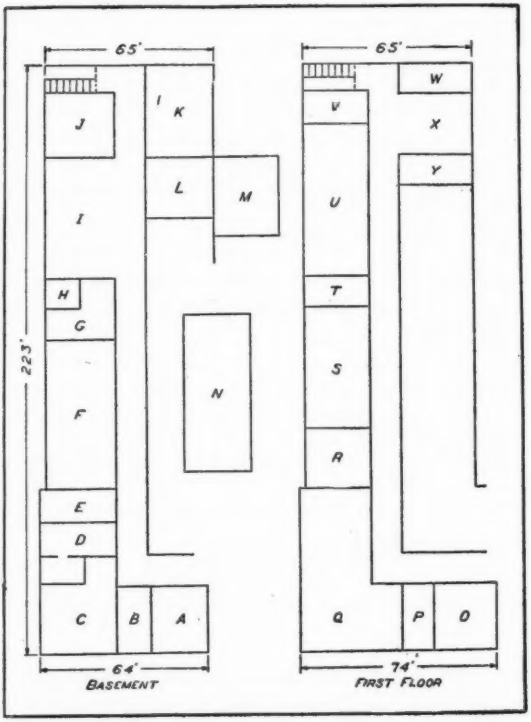
The new course in General Economics, established this year under Professor J. B. Cunningham, has aroused a good deal of interest among the students who are taking it. The sections, of about 25 men each, are small enough so that informal discussion can be carried on at times. The men find that such discussion of abstract economic concepts is a very great help in clarifying their thinking.

F. W. McNair, president of the College, accepted the invitation of the American Mining Congress, held in Milwaukee from September 24 to 29, to address the Congress on the work of the Joint Advisory Committee of the National Industrial Conference Board and also on the work of the Society for the Promotion of Engineering Education.

F. W. Sperr, head of the Mining Department, presided at the Congress over the meetings of the committee on Standardization of Mining Methods.

University of Michigan.—The development of the activities of the Division of Highway Engineering and Highway Transport, the rapid increase in the enrollment of graduate students, as indicated by an increase in the enrollment from twenty-nine in 1919–1920 to one hundred and ten in 1922–

1923 in the professional courses in highway engineering and highway transport, and the expansion of the work of the Highway Laboratory, the average commercial tests each month at present exceeding one thousand, influenced the Board of Regents to allot twenty thousand square feet of working space for the twenty-five rooms assigned for the offices, Davis Library, drafting room, graduate lecture rooms, and laboratories of the Division in the new $700,000 East En-



Plans of the Basement and First Floor of the East Engineering Building Assigned to the Division of Highway Engineering and Highway Transport.

gineering Building, which was opened for use at the beginning of the present collegiate year. The following keys to the plans describe the uses to which the twenty-five rooms in the basement and on the first floor of the north wing have been assigned.

KEY TO BASEMENT FLOOR ROOMS.

Highway Laboratories:

A. Sample Storage Room.
B. Damp Room for Cement and Concrete Specimens.
C. Equipment Room.
D. Locker, Wash and Shower Room.
E. Balance Room.
F. Laboratory for Testing Asphalt Cements, Tars, Oils and Bituminous Mixtures.
G. Laboratory for Testing Paints and Metals.
H. Computing Room.
I. Laboratory for Testing Sand, Gravel and Stone Aggregates.
J. Cement Testing Laboratory.
K. Rock and Brick Testing Laboratory.
L. Receiving Room.
M. Highway Material Bins, Elevator and Delivery Chute.
N. Concrete Testing Laboratory (located under main entrance lobby).

KEY TO FIRST FLOOR ROOMS.

O. Office of Professor of Highway Engineering and Highway Transport and Seminar Room.
P. Stenographer's Office.
Q. Davis Library of Highway Engineering and Highway Transport.
R. and *S.* Lecture Rooms for Graduate Courses.
T. Office of Assistant Professor of Highway Engineering and Highway Transport.
U. Highway Engineering Drafting Room.
V. to *Y.*, inclusive. Offices of Associate Professor of Highway Engineering and Staff of Michigan State Highway Laboratory.

North Carolina State College of Agriculture and Engineering.—During the summer the reorganization of the College was effected, E. C. Brooks being made President of the College and W. C. Riddick, Dean of the School of Engineering.

The Engineering Experiment Station authorized by the legislature is being organized under the direction of H. B. Shaw. Mr. Shaw was formerly Professor of Electrical Engineering and Dean of the Missouri State College, on the Public Service Commission of Missouri and later Director of the Henry L. Doherty Engineering Schools.

The last sessions of the State Legislature authorized the issuing of bonds for the construction of new buildings and additions to the College equipment. At the present time a large new dormitory is being erected; contracts for a large library building and a modern gymnasium have been let and plans are being drawn for a new and up to date power plant. Other additions to the engineering equipment are a vegetable oil mill and a mill for the manufacture of furniture. All electric lines are being put underground and the College Campus otherwise improved. A modern power house will probably be built during the year. All engineering departments are adding materially to their equipments.

The State College, University of North Carolina and Trinity College, Durham, N. C., have organized a local branch of the Society, which is planning to make a careful study of the problems confronting the engineering schools of this State.

Princeton University.—Frederick U. Wilson, who has been in charge of the department of Supplies for some forty years, has retired. He is succeeded by F. A. Heacock who comes from the Virginia Polytechnic Institute.

F. L. Eidman has been appointed Associate Professor of Machine Design and Industrial Practice.

E. P. Culver has been promoted to Assistant Professor of Mechanical Engineering. Professor Culver has been an Instructor for a number of years.

During the last year the schedules for the graduate years in engineering have been prepared.

University of South Carolina.—The State Highway Department of South Carolina has completed the equiping of

the Testing Laboratory built by the University of South Carolina on its campus and has begun making tests on road materials.

Walter E. Rowe, Dean of the School of Engineering, made an extensive exploration of the state during the past summer and took numerous samples of roads materials. He is now planning for the Roads Institute to be held here in January, 1924. All forty-six counties will be represented at this Institute.

L. C. Smith College of Applied Science, Syracuse University.—Capt. Warren A. Lyon, formerly Assistant Professor of Military Science and Tactics, at the University of Illinois, was appointed Instructor in Applied Mathematics, to fill the vacancy created by the resignation of F. E. Verdin, who has accepted a position as District Manager for the Schieffer Electric Co.

Rich D. Whitney, Head of the Department of Electrical Engineering, has been appointed Consulting Engineer for the Bureau of Gas and Electricity for the City of Syracuse.

Dean Louis Mitchell has been in charge of the design and construction of a new Women's Athletic Field for the University. The Field covers an area of about four acres and includes tennis courts, jumping pits, running track, hockey field, and basket ball courts. The total expenditure for the Field will be about $50,000.

University of Utah.—R. B. Ketchum, head of the Department of Civil Engineering is on sabbatical leave during the current academic year. Erasmus Borgquist, engineer of the Utah State Road Department, is temporarily filling Professor Ketchum's place.

Roy F. Newton, of the Chemical Department, University of California, is the new Associate Professor of Metallurgical Research, in active charge of the Department. This department operates in coöperation with the Inter-mountain Station of the United States Bureau of Mines and is devoted wholly

to research work. Besides the ten regular employees in the Department there are five research "fellows."

The Winter Mining Session of the College of Mines, **University of Washington,** will be held for the twenty-eighth year at Seattle from January 4 to March 20, 1924. The courses are open without examination to anyone interested in mining. Expenses consist of the cost of materials actually used and a university fee of $20.

The studies are arranged in four groups: quartz mining, placer mining, coal mining, and ceramics. In addition to the fundamental subjects such as geology, mineralogy, chemistry, and drawing, specialized training is given in ore mining methods, mine surveying, mining law, milling including flotation, assaying; hydraulics, gold-dredging; coal analysis, coal washing, clay testing, manufacture of clay products and cement. The session has proved interesting in past years to many prospectors and mining men from Alaska, British Columbia, and the northwestern states. Details can be obtained by addressing the Dean, College of Mines, Seattle, Washington.

SECTIONS AND BRANCHES.

The University of Colorado Branch held a "get-acquainted" meeting in one of the engineering buildings on the afternoon of November 15 for all members of the faculty and their families. The chief object was to afford an opportunity for all old and new members to mingle with each other. Though a short program was provided, the greater part of the time was given over to informal visiting among the families.

Those who are new on the faculty are as follows: Clarence L. Eckel and Herbert J. Gilkey, Civil Engineering; R. H. Hull, Electrical Engineering; Frank L. Carswell, Paul M. Swingle, Joseph Bunting, and Perry M. Ford, Mathematics; F. C. Walz, Evan R. Jones, and Leonard Jones, Physics; John W. Vanderwilt, Geology; and Walter J. Shea, English.

On November 26 the Branch held a meeting for the discussion of the following topics:

(*a*) Methods of arousing the interest and the initiative of the student.

(*b*) Methods of conducting a design or drafting class, and also a class in shop work.

The meeting was of the informal, round table sort, in which numerous members of the faculty related their experiences.

The committee appointed by Dean Evans to be in charge of the meetings of the Branch for this year consists of Professors Coover, Bauer, and Eckel.

The Minnesota Section of the Society for the Promotion of Engineering Education held its first meeting of the year on November twenty-first, 1923 in the Annex of the Minnesota Union, where fifty-two members and guests gathered for a 5:45 o'clock dinner.

Professor F. B. Rowley, president of the section, presided.

After a short introductory speech by President Rowley, the main speech of the evening was given by Professor Frederic Bass on "The Aims of Engineering Education."

Following the presentation of the interesting paper by Professor Bass, a spirited discussion was held on the same subject by Dean Leland of the Engineering College, Dean Dowrie of the School of Business, Professor F. M. Mann, head of the Department of Architecture, Professor C. A. Mann, head of the Department of Chemical Engineering and Professor S. C. Shipley of the Mechanical Engineering Department.

The meeting was adjourned at 7:45 o'clock. H. B. Wilcox, Secretary.

The fall meeting of the New England Section of the Society for the Promotion of Engineering Education was held at Rhode Island State College, Kingston, Saturday, October 27, 1923.

A majority of the members arrived at Kingston at 10:45 A.M. and were met by automobiles and transported from the station to the college. After a short talk by Dean Anthony, an inspection of the campus and buildings was made under the direction of guides furnished by Dean Wales.

At one o'clock the members were gathered in the dining hall where a very appetizing chicken dinner was served by the college. At 2:30 P.M. the members met in Science Hall for the regular session. The chairman of the section, Dean Anthony, gave a short address, after which the records of the previous meeting were read by the secretary.

A letter from Sheffield Scientific School of Yale University was read, in which an invitation was given to the section to hold its next meeting at New Haven. Voted to accept.

A notice was given by the chairman to the effect that the fall meeting of 1924 would probably be held at the University of Vermont.

The chairman then introduced President Edwards of Rhode Island State College, who welcomed the section and gave a very pleasing address. His talk was mainly a discussion of education and a plea for its betterment.

Professor Scott, of Yale, the retiring president of the Society for the Promotion of Engineering Education, explained

the new aims of the Society, and gave the plans of the development committee up to date.

The meeting was opened to a general discussion. Many of the members availed themselves of the opportunity and made stirring addresses. The meeting dissolved itself into a discussion of a general course in engineering, plans for the development of better engineering teachers, and a plea for the development of clear thinking, both for the teacher and the scholar.

Mr. Williston gave an expression of appreciation for the many courtesies shown by the college during the brief visit, which was unanimously adopted by a rising vote.

The meeting adjourned at 5:45 P.M. Attendance 69, 59 of whom were members.

The following institutions were represented: Rhode Island State College, Tuft's College, University of Maine, Northeastern University, Franklyn College, Harvard University, Brown University, Wentworth Institute, Mass. Inst. of Technology, University of Vermont, Trinity College, Yale University.

H. S. BOARDMAN,
Secretary.

BOOK REVIEWS.

Synopsis of Applicable Mathematics with Tables. By L. Silberstein, Ph.D., Rochester, N. Y. New York, D. Van Nostrand Company, 1923. First published in 1922 at Bell's Mathematical Tables. Cloth, $5\frac{1}{2} \times 8\frac{1}{2}$, xii + 250 pages. $4.50.

This admirably printed volume of convenient size should be within easy reach of every mathematician and every physicist as he goes about his daily work. The First Part, pages 1 to 68, is made up of the usual fundamental mathematical tables conveniently arranged. In the trigonometrical tables the decimal division of the degree has been adopted. The placing of these tables at the beginning of the book seems to add to their accessibility. The Second Part, pages 71 to 240, contains an almost exhaustive collection of the less elementary mathematical formulæ, theorems, and tables of special functions. A separate index to the tables would add somewhat to the very great reference value of the volume. To enumerate all of the topics covered would be to reproduce the index which fills nine double column pages and contains more than eight hundred items, ranging from the Theory of Numbers to Tensor Calculus. Some of the topics not involving tables are Infinite Series and Products, Trancendental Numbers and Equations, Matrices, Definite Integrals, Fourier Series and Integrals, Functions of a Complex Variable, Calculus of Probabilities and Theory of Errors, Differential Geometry, Non-Euclidean Geometry, Projective Geometry, Vector Algebra, and Analysis, and Quaternions. Some topics requiring tables are Theory of Numbers, Hyperbolic Functions, Derivatives and Integrals, Fresnel's Integrals, Error Function, Gamma Function, Approximate Quadriture, Spherical Harmonics, Bessel Functions, and Elliptic Functions. The words "Synopsis" and "Applicable" as used in the new title are

well chosen and accurately express the aim and the accomplishment of the author.

K. D. S.

Design of Steam Boilers and Pressure Vessels. G. B. HAVEN and G. W. SWETT. John Wiley and Sons. Second Edition, Revised 1923. 435 pages, 206 figures.

Contents: General Principles, Stresses in Pressure Vessels, Fastenings by Riveted Joints, General Propositions, Design of a Horizontal Return Tubular Boiler, Design of a Dry Back Scotch Boiler, Design of a Locomotive Type Boiler, Tank Design, Water Tube Boiler Design.

This is probably the most complete work on the subject. Theory and practice have been skillfully combined. The most direct proceedure in the design of pressure vessels showing use of formulae and necessity of logical assumptions possible only through experience has been clearly shown. In the last six chapters the complete design of several types of apparatus, including all necessary calculations, illustrates to the student the proper application of principles brought out in the first part of the book.

W. F. W.